

Neptune Software Introduction

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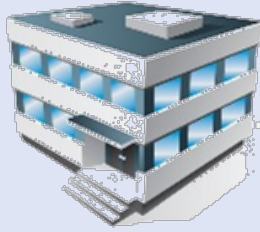
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Naval Research Laboratory
Washington D.C.

Naval Research Lab (NRL) Satellite Ground System Implementation



Mission Operations Center (MOC)	Satellite Operations Center (SOC)	Ground Station(s)	Data Processing
<ul style="list-style-type: none"> • Web-based mission planning system • Provides: <ul style="list-style-type: none"> • User requests • Satellite modeling • Tasking • scheduling • Maneuver planning • Government owned 	<ul style="list-style-type: none"> • C2 software used for satellite development, integration & test (I&T), launch, and operations • Government owned 	<ul style="list-style-type: none"> • Digital → RF (commanding) • RF → Digital (telemetry) • Shared antennas • "Lights Out" Automation • Data Distribution 	<ul style="list-style-type: none"> • Mission specific implementation
	 <p>NRL Blossom Point Tracking Facility (BPTF)</p>		

VMOC, Neptune software, and Blossom Point provide integrated and capable satellite operations

Neptune Software Overview



- NRL Neptune software is a multi-mission command and control (C2) suite that meets the following broad requirements:
 - Provide C2 for any number of satellite programs using a common code base
 - Provide control and status for all ground hardware required to support the missions
 - Support all mission phases (box-level testing through operations)
 - Automate everything possible to increase reliability and reduce human errors



Experience and History of Success

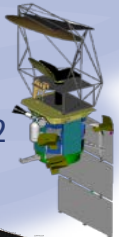


- 30+ years of satellite integration, test, and operations
- Code base continually modernized
 - Code originally written in Fortran under VMS
 - Rewritten to C under Solaris
 - Ported to Linux operating system using C/C++/Java in mid-2000s
 - Current conversion project from 32-bit to 64-bit to take advantage of hardware advances and meet future OS and 3rd party requirements

SENSE – 2013



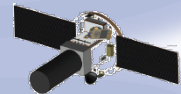
WindSat
(Coriolis) – 2012



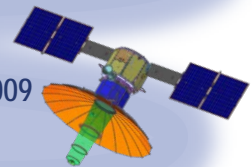
Colony I
cubesats– 2010



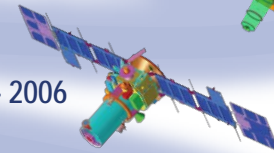
RPP – 2011



TacSat-4 – 2009



TIE Payload – 2006



TIPS – 1998



TacSat-1 – 2003



Clementine
(DSPSE) – 1994



ICM – 1995



LACE – 1989



Living Plume Shield
(LIPS) – 1980s



Multiple Satellite
Dispenser (MSD) – 1970s



Selected Neptune software supported missions:

Four Important Concepts



Government-Off-The-Shelf (GOTS)

- Neptune software is managed by NRL
- NRL owns the source code and holds unrestricted rights to software
- NRL provides Neptune software development and sustainment on cost reimbursable basis

Single Baseline

- Applied across all sites and program phases
- Users share development & sustainment costs
- Reliability and stability promoted by supporting diverse missions

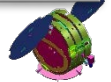
Multi-Mission

- Designed from the ground up as a true multi-mission, site configurable C2 package
- Separation of mission unique from core software maximizes reuse and cost savings
- Users define their CONOPS

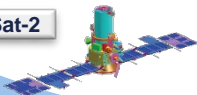
Automation

- Pre-defined operator tasks are scripted into software by site engineers
- Tunable from no automation to full 'lights out'
- Hundreds of daily contacts for many missions can be reliably and cost-effectively operated by minimal staff

TacSat-1



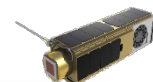
TacSat-2



TacSat-4



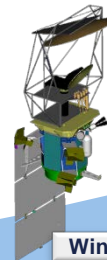
SENSE



RPP



WindSat



Argos

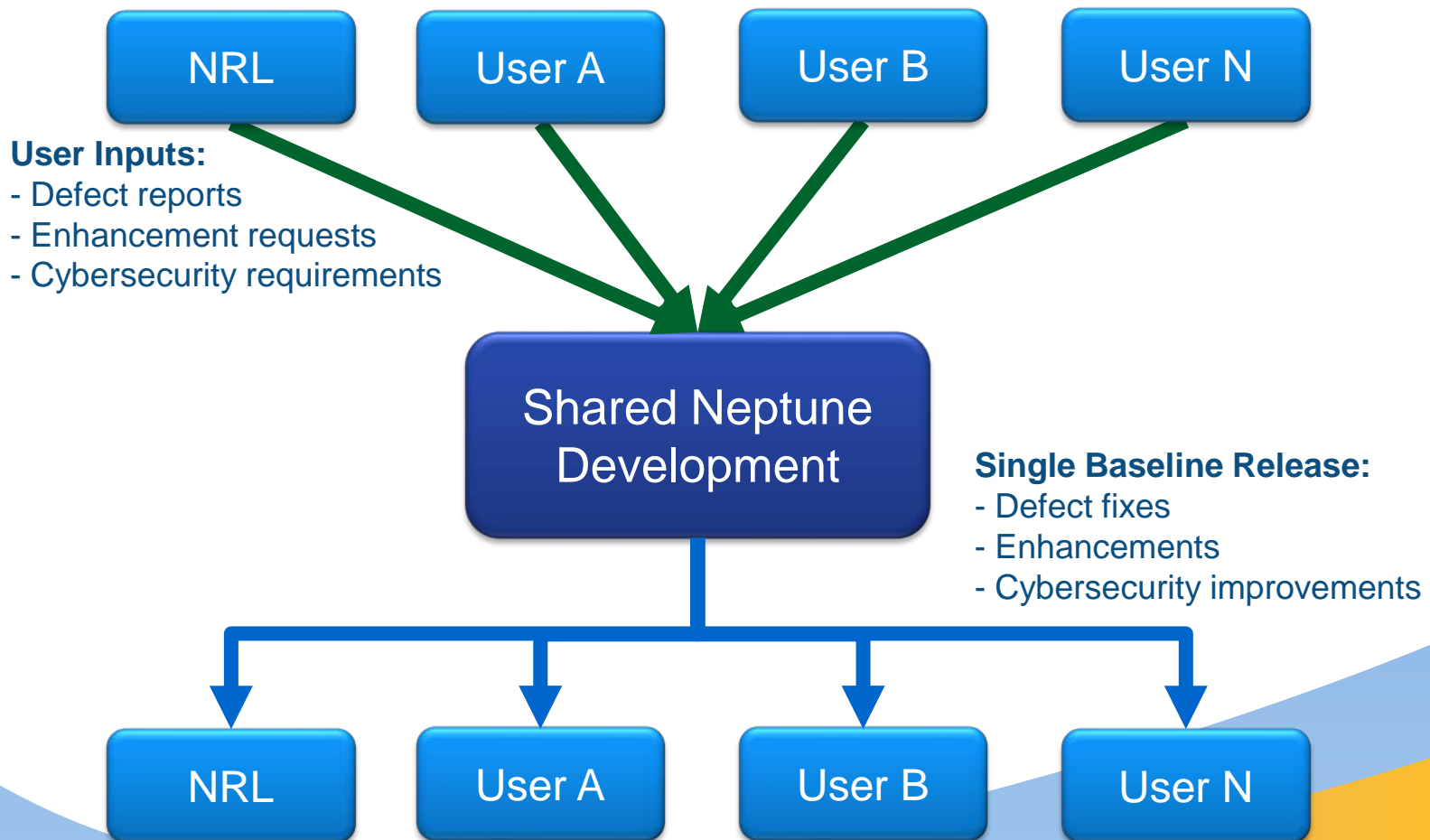


CubeSat Colony I, II



Single Baseline

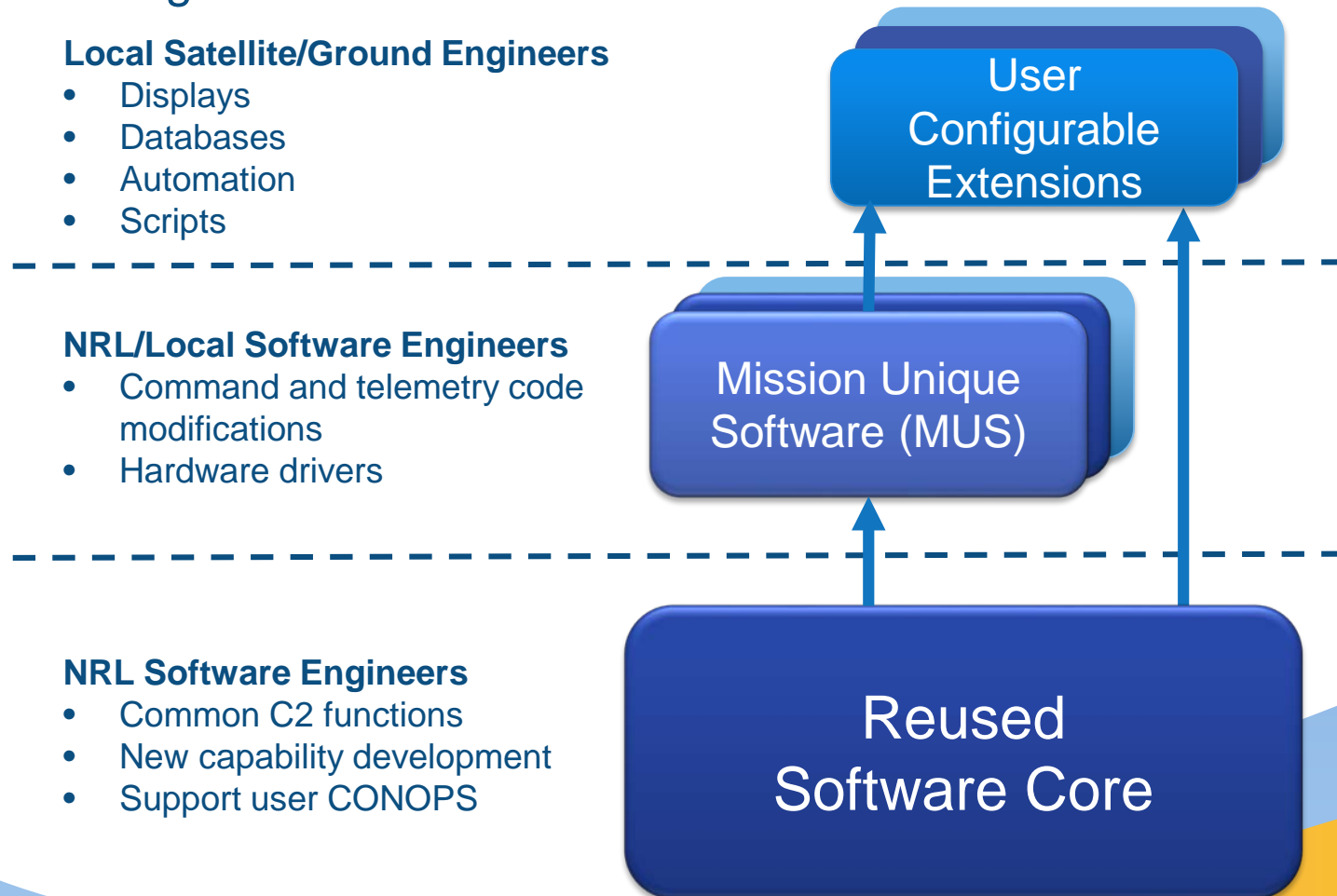
- Neptune software users fund development and sustainment through the single baseline concept



Multi-Mission



- Neptune software supports multiple satellites at same SOC
- Software development distributed to most knowledgeable and cost-effective engineers



Summary



- Neptune software has a history of success supporting diverse missions
 - GOTS derives from government ownership and management of the code
 - Single baseline to share development and sustainment
 - Multi-mission architecture to reuse core software and allow users to configure system
 - Automation to increase reliability, resiliency, and decrease costs
- Programs using the Neptune software realize many benefits
 - Software stability
 - Lower, more predictable costs for individual programs
 - Advanced capabilities based on requirements from multiple users

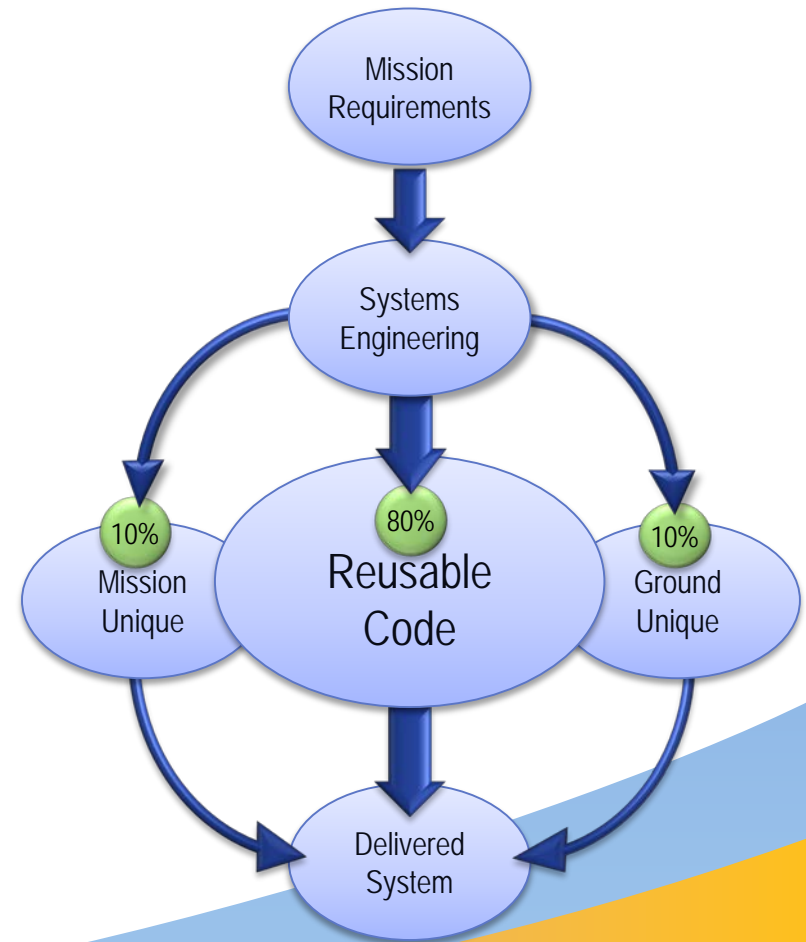


Backup

Government Off-The-Shelf



- NRL developed most cost-effective solution for multiple internal programs
- NRL experienced in developing and configuring Neptune software for external users
- Flexible funding mechanisms for users
- Local user participation encouraged



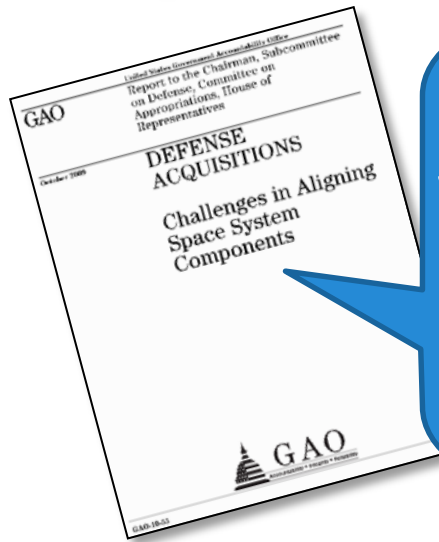
Automation



- Acts as the ideal operator
 - Only follows pre-defined and approved scripts
 - Same inputs → same conclusion
- Monitors spacecraft telemetry and ground site status
 - When anomalous values detected, follows pre-approved procedures
- Additionally monitors computer processes, networks, and facility alarms (temperature, fire, power, etc.)
- Local satellite/mission engineers develop, control, and use the automation
- Operating “lights out” at NRL’s BPTF since 2007
 - Hundreds of thousands of contacts executed
 - Staffing reduced to satellite engineers working business hours
 - Increased reliability and resilience
 - Decreased cost



Neptune SOC2SOC Shares Ground Station Resources



“Develop DOD-wide guidance, specific to space systems, to allow for the integration and consolidation, to the extent feasible, of DOD’s current and future satellite ground control systems via common ground architecture or by other similar means”

– GAO-10-55 p. 25

- Users establish CONOPS/priorities and configure Neptune software databases
- SOC2SOC enables antenna sharing between ground stations providing users additional satellite contacts during equipment idle time
- Hybrid solution of “sharing” the various dedicated antenna systems
- Operating successfully on the SENSE satellite program since 2013

External Evaluations



- Neptune software is “a highly attractive and accessible architecture” that “makes effective use of automated ground operations” and “incorporates key characteristics that could benefit microsats” – *USAF Scientific Advisory Board Report on Microsatellite Mission Applications p. xii*
- “One satellite control facility operated by the Navy, known as Blossom Point, does operate a ground system that can control a variety of national security satellites. The facility uses a common approach (architecture) to command and control the satellites as well as receive and analyze data and information transmitted from the satellites. The common approach allows the facility to reuse a large percentage of the existing software across multiple satellites” – *GAO-10-55 p. 23*
- Neptune software is “a proven product” that “has been successfully used for a number of years to support NRL missions, other Government S&T missions, other Government residual missions, and commercial missions” – *Aerospace report TOR-2014-00448 p. 54*